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Grand visions and pragmatic integration: Exploring the evolution of Europe's electricity regime

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Abstract

In this paper we develop a socio-technical analysis of the European electricity system. We show that the relationship between high level *grand visions* of an integrated European system and more *pragmatic* bottom-up processes of electricity system development have been a feature of the European regime for coordinating cross-border electricity flows since the 1920s. Following a period when radically different visions of a European system were proposed, the nation-state emerged as the key site of system building and constituted the core of the technological and institutional configuration. However, European *grand visions* persisted and this led to the creation of various forms of transnational collaboration and coordination. We discuss whether this inherited technical and institutional configuration is compatible with the contemporary desire for a European low carbon transition and we emphasise the need for more detailed analysis of socio-technical *regimes* and their dynamics to inform policy and enrich transitions theory.

Keywords: Socio-technical Regimes; Low Carbon Transitions; Internal Electricity Market; Energy Union

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1 Introduction

This paper develops a historical perspective on the relationship between a European internal electricity market (IEM) and national energy policy responses to the decarbonisation agenda. While much of the recent debate and discussion about European energy and climate policy is focused on more integrated energy and climate policy in the EU, it tends to be conducted without recognition of the history of multi-level alignments and tensions between pan-European and (sub-) national electricity governance. In this paper we show that the relationship between high level *grand visions* of an integrated European system and more *pragmatic* bottom-up processes of electricity system development primarily initiated at the national level have been a feature of the European system since the concept was first proposed in the 1920s. Drawing on socio-technical systems theory, we show that the European electricity *regime* for coordinating cross-border flows was shaped through the evolution of this relationship. At times during the period we analyse, from the 1920s to the present day, the relative emphasis has been on the national or the pan-European, and there have been periods of tension and synergy between them.

The paper is written with a view to providing historical depth to the current tension at the heart of European energy policy. Despite the efforts of the European Union (EU) in creating a harmonised approach to decarbonisation[2], electricity system transition has largely been pursued at the nation-state level through regulatory interventions and policies, and as a result has been an uneven process. This unevenness is illustrated in figure 1 below which shows the deployment of renewables in the electricity systems of a selected number of European countries. While there are, for example, some signs of convergence between Germany and the UK, the general picture is that countries have had different starting points and are moving at different speeds in terms of their low carbon transitions, exemplified for example by the rapid growth of large scale wind power in the UK in recent years. This differential growth in renewables deployment is largely as a result of national-level policies such as feed-in tariffs, capacity auctions and tradable certificates, rather than driven by pan-European energy and carbon price signals.

[2] Primarily through its two agreements it has set EU-wide targets for decarbonisation. A reduction in greenhouse gas emissions of at least 20% by 2020 agreed in 2008 (Energy and Climate Package) and 40% by 2030 agreed in 2014 (Energy and Climate Framework), both from 1990 levels.

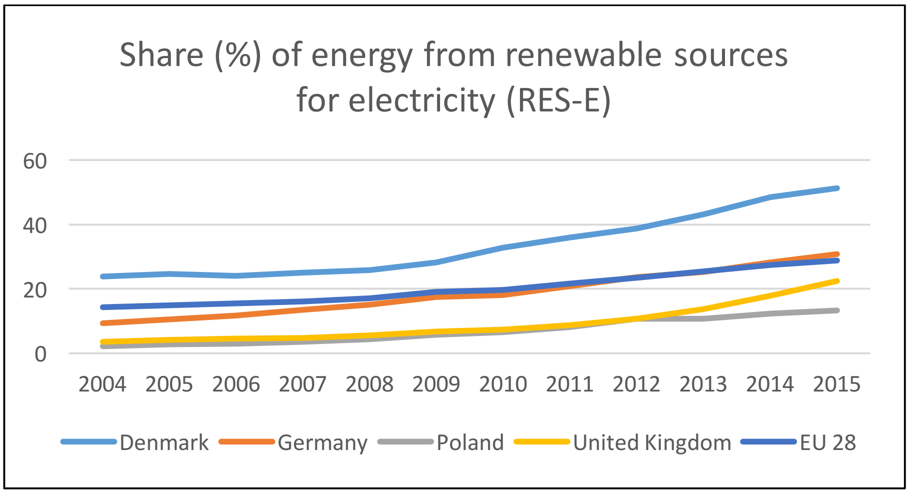

Figure 1: Renewables deployment in selected European countries. Data from http://ec.europa.eu/eurostat/web/energy/data/shares

The process described above has resulted in a divergence between countries as they pursue different policy measures and low carbon transition pathways, leading to what some commentators have referred to as a 're-nationalisation of energy policy' in Europe (Buchan and Keay, 2016a). This is a key concern of proposals to reform electricity market governance contained in the EU's 2016 'Winter Package' of proposals.[3]

The paper has two main aims. Firstly, to develop an understanding of the historical origins of this key tension between high-level visions of a single and seamless European system of electricity flows, and more pragmatic processes of system building primarily located at the national level. This is with a view to informing contemporary policy debates about market design, the integration of renewables and the relationship between different levels and scales of electricity system governance in Europe. The dynamic between grand visions and pragmatic integration, we argue, provides a useful conceptual lens through which to analyse key continuities which have shaped the *European style*[4] of electricity integration. We show how over the decades the rules governing cross-border electricity flows in Europe emerged as an outcome of a complex political configuration where jurisdiction over the operation of the technical systems largely resided at the national level, but transnational organisations such as the European Commission and various industry and regulatory coordination bodies have exerted an important influence.

Our second aim is to develop and extend the socio-technical systems approach to the analysis of electricity integration and low carbon transition in a European policy context. Much of the current research on European electricity integration is based on techno-economic appraisals of the economic benefits of integration, which typically downplay the complex political and institutional challenges involved in large scale system change. We draw on the *regime* concept developed in the sustainability transitions literature (Markard et al., 2012) to open up our understanding of the interplay between technologies and institutions in the shaping of the European electricity system. Regimes, broadly defined, are

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[3] https://ec.europa.eu/energy/en/news/commission-proposes-new-rules-consumer-centred-clean-energy-transition

[4] We draw here from Thomas Hughes (1983). He used the concept of technological style to denote a specific way of using and institutionalising electricity within a particular cultural, geographical and political context.

the rules which provide stability to large technological systems such as electricity supply (Geels, 2011, Steward, 2012). They are held together and gain stability from mutually reinforcing interactions between technologies and institutions and tend to change only over long timescales, therefore a historical approach is required in order to understand their characteristics and evolution. This in turn enables contemporary policy debates about regime transitions to be contextualised and, crucially, the influence of historical continuities to be uncovered and explored. A key aim of socio-technical systems research has been to understand the processes through which technologies and institutions become intertwined; these typically remain hidden in contemporary policy debates, but have been shown to be highly influential in processes of electricity system change (David and Bunn, 1988, Unruh, 2000).

The remainder of the paper is structured as follows: In the next section we outline our analytical approach which, as mentioned above, is based on socio-technical systems theory, and in particular the analysis of regimes and transitions. We discuss how socio-technical regimes and their dynamics have been conceptualised in different strands of this literature. Following this, we outline how our approach to the analysis of the European electricity regime contributes to recent debates in this field, in particular about the role of regimes and incumbent actors in innovation processes. We pay particular attention to Van Der Vleuten and Högselius' call for a 'symmetrical' approach to transitions analysis which stresses the ability of regimes to adapt to uncertainty and disruptions, and the need for openness to both incumbent and niche-led innovation processes (Van Der Vleuten and Högselius, 2012). Following this we begin the empirical study by outlining how the European regime governing cross-border electricity flows has been influenced and shaped by interactions and tensions between national and transnational level drivers of change in three periods. The *first* examines the early period of European electricity integration, beginning with the inter-war years when many grand visions were proposed, and continuing into to the post-war era when pragmatic integration around core national systems was established. Rather than the creation of an integrated European system, this period saw the emergence of an embryonic market as a means of linking national systems. In the *second* we outline how the European market, which became established in the 2000s, has been orientated around a new market-based grand vision, the design of which incorporated important features of the earlier pragmatic integration approach. Through this analysis we can discern a distinctive style of electricity integration, where national systems form the core and the European system is constituted by a higher level layer of exchange and trading which has been built up between these national systems. The *third* is the contemporary period. Here discuss how the interaction of the market and low carbon agendas are creating tensions in this regime alignment and we discuss key responses and reforms which have been proposed by the EU Commission in order to address these. In the final section we discuss our findings in relation to contemporary policy debates and how our work contributes to an understanding of European low carbon transitions.

2 Analytical approach

2.1 Socio-technical regime analysis

The basis of the socio-technical approach is that large technical systems, such as electricity supply, are composed of interactions and inter-relationships, both between different technical artefacts as part of complex technical systems, and between technical and nontechnical components, such as laws, regulations, and economic frameworks (Hughes, 1983)(Mitchell, 2008). Such systems, by their nature, engender continuity as they are composed of a complex set of interlocking and mutually reinforcing social and technical components; what Thomas Hughes referred to as the "seamless web". Concepts such as technological momentum (Hughes, 1983), techno-institutional complexes and lock-in (Unruh, 2000), path dependency (David and Bunn, 1988), and regimes (Nelson and Winter, 1977) have all been used to describe the tendency towards continuity in technical systems.

The issue of continuity and system change has recently been addressed in work in the sustainability transitions field (Smith et al., 2010, Markard et al., 2012). Rather than focusing on how systems emerge, grow and become embedded in society, as was largely (though not exclusively) the case in earlier work on large technological systems (LTS) (Coutard, 1999, Ewertsson and Ingelstam, 2004, van der Vleuten, 2004, Mayntz and Hughes, 1988, Kaijser and Hedin, 1995), the emphasis is on processes which lead to fundamental changes in established regimes, for example through fragmentation or decline. Regimes in this literature are the "the semi-coherent set of rules that orient and coordinate the activities of the social groups that reproduce the various elements of socio-technical systems" (Geels, 2011: p. 27). A transition is the shift from one regime type to another, a process which is conceptualised by scholars in this field by using a multi-level perspective (MLP) involving landscapes, regimes and niches: *Regimes* can be destabilised by radical innovations which are developed by innovators in micro-level *niches* and also by macro-level external *landscape* effects, like warfare or oil crises, which are beyond the direct influence of regime and niche level actors. While the LTS literature concentrated on the early stages of technological development and the role of system builders, the MLP approach is more attuned to dynamic interactions between radical innovations, external landscape effects and incumbent regimes.

Many of the early contributions to the MLP literature focused on innovation processes at the niche level and on disruptive patterns of system change (Kemp et al., 1998, Hoogma et al., 2002). However, more recently the analysis of regime level dynamics and the role of incumbents has begun to feature more in this literature (Bolton et al., 2016). This line of research was opened up following criticisms of a "niche bias" in transitions research. In MLP terminology, a lack of attention to the "adaptive capacity" of regimes in the face of disruptive change from the niche and landscape levels (Berkhout et al., 2004). MLP scholars (Geels and Schot (2007) responded to this criticism by proposing a more varied set of potential transition pathways based on interactions between the three levels. This typology incorporates more scope for regime agency during transition processes; for example, in a transformation path: "new regimes grow out of old regimes through cumulative adjustments and reorientations"; while during a reproduction process "accumulated incremental innovations" enable regimes to slowly adapt to moderate external pressures for change. Following on from this largely theoretical discussion of transition mechanisms and typologies, a number of empirical studies have illustrated how incumbents engage in *both* incremental and radical innovation (Bergek et al., 2013, Ottosson and Magnusson, 2013) and have discussed the implications for "continuity-based" system change for energy innovation policy (Winskel and Radcliffe, 2014).

Historians of technology Erik Van Der Vleuten and Per Högselius have developed an empirical approach to regime analysis which is particularly relevant to both this debate and our study of European electricity (Van Der Vleuten and Högselius, 2012). They criticise what they regard an overly mechanistic multi-level approach in transition studies for overemphasising dis-continuities, external sources of system change, and for not taking into account the capacity of incumbent actors to incrementally adapt to and even shape change in accordance with their capacities and economic interests. Drawing on historical evidence of transnational gas and electricity regimes in Europe, they make the case for a "symmetrical" approach which considers how regimes develop and change through both radical and incremental forms of innovation and system change.

Building a case for a transnational perspective on transitions, and studying the evolving European electricity and gas infrastructures, their work makes three key additions to existing transitions theory. Firstly, the incumbents at the European scale are not only resisting change. To various degrees, European energy producers, users, and regulators also pushed for change, whether in environmental policies or market liberalisation. Secondly, the nature of the regime itself has never been a single unified entity, rather a geographically varied and loosely coordinated assemblage held together by a mix of top-down and bottom-up processes. Thirdly, incumbent energy regimes do not form closed systems, but are the result of continuous interactions between their own dynamics and seemingly more exogenous developments in society, including oil crises, the Kyoto Protocol, or financial crises, as well as radical energy innovations emerging from niches.

2.2 Grand visions and pragmatic integration

In this paper we seek to extend and develop Van Der Vleuten and Högselius' work on European energy regime analysis. Their study looked across the European electricity and gas sectors and provided a number of case studies – environmental policies, security of supply concerns, liberalisation reforms – of how these regimes adapted to *landscape* changes and *niche* innovations. We draw on their material and approach, but focus more on the market aspects of electricity integration and how, today, this is interacting with the decarbonisation agenda. We also further the conceptualisation of European energy regimes by moving away from the rather mechanistic multi-level perspective on regime transition (Williams et al., 2014). We propose an alternative approach which examines how the European electricity regime evolved during different phases through efforts to pursue transnational *grand visions* of a coherent, seamless and integrated European system through largely bottom-up processes of *pragmatic integration*. Grand visions and pragmatic integration can be summarised as follows:

1. *Grand visions*: A belief that integrating systems at the European scale provides efficiency benefits which go beyond those which can be achieved at a national or sub-national level. This belief can find expression in ambitious transnational infrastructure schemes and network blueprints, and politically motivated initiatives to integrate national policies and strategies. They tend to embody high level political ideals and economic logics and imply radical change if implemented.
2. *Pragmatic integration*: A recognition that national systems have become strongly embedded and a view that exchange and trading between systems offers a means of ensuring their stability and improving efficiency at the margin. This implies incremental processes of integration and sees a European market is an addition rather than an alternative to the hegemony of national systems.

Grand visions and pragmatic integration are different lenses and perspectives on electricity integration which, as ideal types, have radically different implications in terms of the technical and institutional organisation of the electricity system. However, as we outline below, a key characteristic of European electricity integration during different phases has been one of increasing co-existence and interdependency between them. The analysis of the European electricity regime through this lens helps to explain how the multi-level political alignment and balance of power and influence over system change between the national and the European levels emerged. This has become a key continuity and is shaping current responses to the low carbon transition.

As we outline in detail below, regime evolution through a process of pursuing grand visions through pragmatic integration processes unfolded gradually during the course of the 20th century. In the early decades of electricity integration many grand visions were proposed but in the post-war era pragmatic integration around core national systems was established. Rather than the creation of an integrated European system, this period saw the emergence of an embryonic European market as a means of linking national systems. We outline how the European market, which became established in the 2000s, has been based on a new market-based grand vision, the design of which incorporated important features of the earlier pragmatic integration approach. We subsequently discuss how today we are seeing a fracturing of this regime alignment.

3 Historical origins of a European electricity regime

3.1 An era of grand technological visions

Shortly after the First World War, during a period of combined energy, economic, and political crises, electricity gained the attention of policy-makers. As a consequence, the first substantive rules and regulations governing the sector were developed on a national as well as an international scale. Early systems for industrial demand were also developed close to resource bases where production sites in emerging industries like the printing, metallurgy, and the engineering sector were supplied, such as the High Rhine bordering Germany and Switzerland (Gugerli, 1994). Enabled by innovations in high voltage transmission technology, electricity systems became less reliant on local generation sources to meet demand and hence they could be expanded to link and incorporate a wider range of geographically dispersed resources. A new engineering-logic emerged, with the question of how to achieve an "economic mix" (Hughes, 1983) of different generating sources becoming central. In key regions such as the German-Swiss border engineers were concerned with how to incorporate into one system hydropower resources, which was high capital costs and low running costs but with seasonally varying peak production, with thermal power stations, which provided a steady base-load at relatively high running costs.

Within nation-states the 1910s and '20s saw an increasing politicisation of electricity systems and their evolution, resulting in a change from the dominant role of private companies (often alliances between manufacturers of electrical equipment and financial institutions), to a larger role for public authorities (Hausman et al., 2008). Both national and regional authorities (e.g. on the level of provinces or Bundesländer) started to legislate and regulate, and also took on a more active in building networks. Crucially, national and regional authorities did not see electricity as a market system, but rather as a public utility (Bouneau et al, 2007, p.35). Whereas companies operated on an international level, and thus also transmitted electricity across borders from the dawn of the 20th century, the nationalist tendencies of the interwar years prioritised national utilisation of resources, later dubbed "the nationalisation of nature" (White, 1999). For electricity companies who typically operated across borders, this meant restricting their business opportunities and limiting their rationalisation efforts to *within* national borders. At various international conferences, engineers argued that the pursuit of an economic mix should supercede territorial borders and any political considerations; a logic which is summarised in the following quote from a prominent engineer of the time: "[international connections] can never have any but a useful and beneficial effect from all points of view" (Landry, 1926: p. 1117).

As technology and power systems engineering knowledge advanced, the idea of placing control over the system into the hands of a single national or regional operator gained prominence. The growing importance of electricity for industry and society made authorities more aware of security of supply issues and the idea of electricity as a key strategic good for society gained political traction. In response, several countries installed so-called *load dispatchers*; a centralised office in charge of managing regional grids and ensuring an economic mix between various types of generation sources (Bouneau, 1994, Stier, 2006, Verbong et al., 1998). This added a strong regulating governance layer to what had been up until then a largely private industry, and it facilitated the growth of networks and a more optimal use of resources.

The question of what remit these load dispatchers should have and the geographical scope of their operations became a key point of discussion and debate. One option concerned the construction of national grids, essentially interconnecting the existing local and increasingly regional networks. One of the first explicit visions of this kind came from Munich engineer Oskar von Miller who proposed the creation of a German national system with the grid of the Rheinisch-Westfälisch Elektrizitätswerk (RWE) as its backbone, shown in figure 2 below (Füssl, 2005). Although a private cooperation, the Essen-based RWE had municipalities who operated their local systems as public utilities as majority stock owners. Visions of a European system sought to do virtually the same in terms of achieving efficiencies from aggregating smaller systems, but on a much grander scale. For example, electrical engineer and entrepreneur Oskar Oliven, a director of an international company building and running electrical facilities, envisioned the RWE regional system as part of a European-wide grid (Oliven, 1930). The scheme, shown in figure 3 (Génissieu, 1926), envisioned arteries of transmission lines spanning the European continent, connecting large thermal generators and hydro plants with major sites of consumption.

While the geographic composition of these European systems differed, the basic engineering-logics of both visions were quite similar; i.e., electricity generation, often distant from sites of consumption, combined with large-scale synchronised transmission lines based on the use of novel high voltage technologies which had not yet been put into practice. In both instances the proponents of these grand visions they saw themselves as technicians improving societies, pursuing an alternative and non-political pathway (Lagendijk, 2012). A key difference was that they sought to appeal to different political constituencies and they had an associated difference in what might be termed an ideological mix.

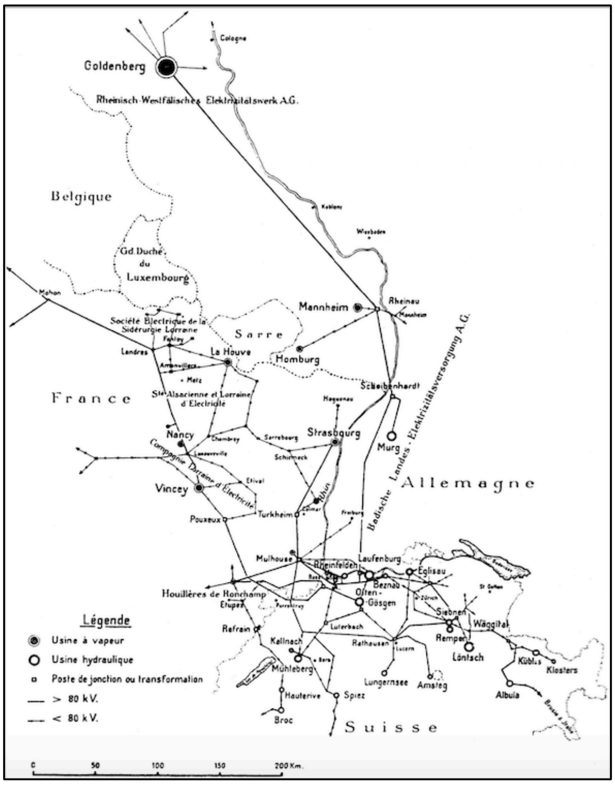

Figure 2: Rheinisch-Westfälisch Elektrizitätswerk (RWE) system (Génissieu, 1926)

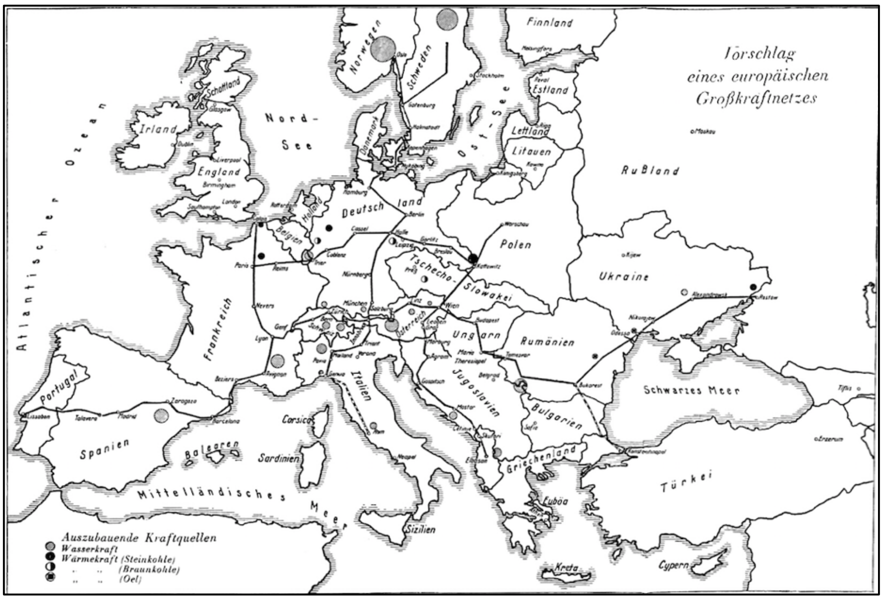

Figure 3: Oliven's vision (Oliven, 1930)

Many of the early visions proposed by individual engineers and companies had an instrumental purpose, to position politics in a way which enabled a particular technical logic to be inscribed into the design and configuration of the electricity system. This led to specific geographies of a European system being proposed which, for example, included or excluded the Soviet Union or Great Britain, depending on the priorities and interests of the particular proponent. However, while engineers at least rhetorically tried to refrain from engaging in politics, energy and electricity systems increasingly become an issue in intergovernmental policy-making. This "technocratic internationalist" engineering agenda, which was strongly influenced by the rise of the European movement (Schot and Lagendijk, 2008), evolved into a more heterogeneous ensemble of politicians, nobility, intellectuals, entrepreneurs, and engineers. The connection to a European movement and international politics helped engineers to conceive of a European system as it gave them political legitimacy, but it also brought with it resources to develop the knowledge base and explore the technical and economic feasibility of various system configurations. Rather than the more pragmatic actions on the national level, these proposals should be seen as European grand visions.

In practice, however, the inter-war period firmly established nationally-based electricity regimes, but with a gradual steps towards fulfilling versions of the European grand vision. A key development was the League of Nations deciding to take the notion of transnational electricity systems up for further study. The attention and resources that the Geneva institution devoted to electricity interconnection was a turning point in the development of the engineering grand vision from the early 1930s. Prior to this the League had tried to get countries to agree to ambitious legislation on the exploitation of international watercourses and the international transmission of electricity. This led to little ratification however, and from the early 1930s an approach which tried to merge the national and European treads in resource governance and design of large technical systems was pursued. At the same time, engineers and representatives of private utilities argued to keep borders open, but instead of advocating for the construction of a European grid with one load dispatch centre, an ambitious approach which seemed out of sync with political and economic circumstances at the time, these actors opted instead for a gradual extension of regional and national networks, which they felt was the most feasible route to eventually achieving a European system. Thus, the grand vision of a newly-built European network seemed to be giving way to the pragmatic approach with network-integration first pursued at the nation-state level, similar to Von Miller's plan in Germany, and a possible European grid emerging out of the interconnection of these grids. While these official plans were put on hold during the next war, a European agenda had been set for engineers and policy-makers alike for further rationalising electricity supply across national borders. However, at the European level no genuine and robust governance structure was put in place as international economic and political tensions stifled the League's work.

3.2 Hidden integration after World War Two

The inter-war period saw the emergence of a pragmatic national approach to integration which was shaped by an alignment of engineering logics and political processes. This shaped the expectations of engineers and planners which became largely focused on ways of making the existing systems more robust, secure, and efficient (Lagendijk, 2013). Efforts were made by these actors to ensure that national system development was done in a way which did not close off the idea of a European system, particularly in continental western Europe. In practice, thus, the European vision needed to be synchronised (quite literally) with these national developments. Also, further complicating the international picture were Cold War tensions which created significant political impediments to European grand visions and lead to a virtual separation between Western, and Central and Eastern Europe.

In many ways there was a significant level of continuity between the interwar and wartime periods. National public authorities continued to extend their influence and remit over system design and coordination decisions, resulting in a minimal level of foreign interference. In some countries, such as France and the UK, this led to full-blown nationalisation of the energy sectors, whereas in others alliances of regional governments and private utilities remained in control (e.g. Germany) (Gilbert et al., 1996: p.5). Largely autonomous private companies, who were instrumental and powerful since the dawn of the 20th century, lost ground (Hausman et al., 2008, p. 223 & 234-238). Dubbed a process of "domestication" by Hausman et al., this gave rise to vertically integrated public/semi-public electricity companies.

Alongside this domestic governance layer, new international governance practices became increasingly institutionalised through a process of "hidden integration" led by industrialists and technical experts, somewhat removed from high politics (Misa and Schot, 2005). The Organisation for Economic European Cooperation (OEEC, founded in 1948) which was established to distribute the Marshall Plan funds emerged as a key actor in this context. In its 1950 report "Interconnected Power Systems in the USA and Western Europe" (OEEC, 1950) it discussed several options for electricity cooperation and interconnection. Although plans for supranational ownership of power plants and transmission lines were put forward, for political reasons and because of the increasingly national orientation of large energy corporations, these were consistently voted down by energy representatives of Western European countries for being incompatible with the pragmatic and national vision (Lagendijk, 2008, pp. 124–131). Voluntary pooling of power was identified as being more feasible as it provided national systems with the option of reaping the benefits of an economic mix at a transnational scale and mutual assistance in case of emergencies, whilst keeping the smaller national and sub-national units firmly under national control.

Such pooling arrangements would however required stronger technical and institutional integration, and in 1951 eight countries founded the Union for the Coordination of Production and Transmission of Electricity[5] (UCPTE). This was initially an informal union and composed of individual representatives from the national network operators (see figure 4 for an overview of the evolution of UCPTE membership). The UCPTE began its work by establishing a set of operational rules to improve efficiencies from surplus hydro power and by pooling reserve capacity among the participating networks. In contrast to today's power pools, these were non-monetary forms of cooperation and did not involve sophisticated market rules, but the approach can be seen as an embryo of today's market-based regime. The UCPTE system aimed to make more efficient use of resources whilst retaining a significant level of national sovereignty and autonomy. Therefore, the use of international connections was modest at best; international energy flows were important from a qualitative point of view – solving temporary shortages and exchanging surplus hydroelectricity – but quantitatively rather limited and variable (Verbong, 2006).

[5] Initially composed of the integrated energy companies in Belgium, Germany, France, Italy, Luxembourg, the Netherlands, Austria and Switzerland.

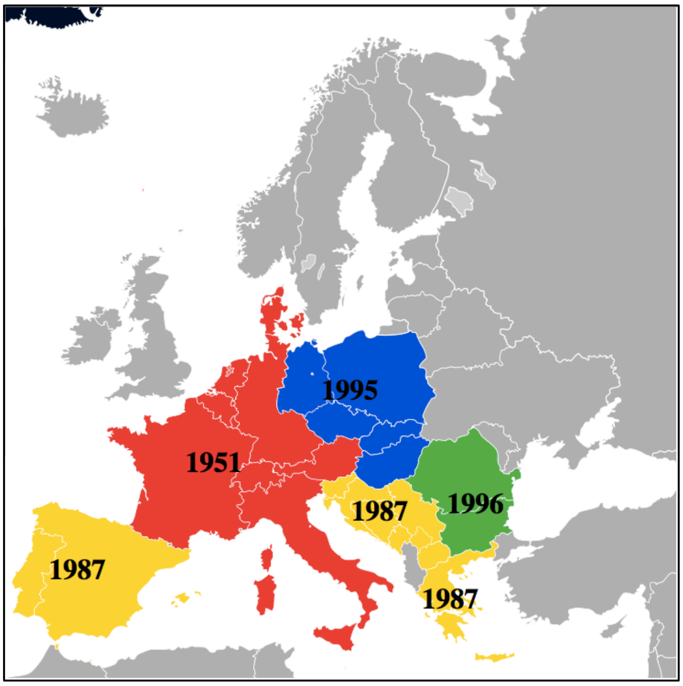

Figure 4: UCPTE membership 1951-1996. Compiled by the authors.

By the end of the 1950s, the systems of UCPTE members operated under common technical conditions, at the single frequency of 50Hz. The technological system tightly coupled the national systems with a European logic of rationality and efficiency. The result was a high degree of interdependence between national systems, where temporary shortages or surpluses in one country triggered an automatic response in adjacent countries, resulting in a very reliable electricity supply system, with no large cross-border disturbances until 2003 (Lagendijk and Van der Vleuten, 2013). By the end of the 20th century the technical interconnection between transmission system operators (TSOs) within Europe was even tighter, but also geographically larger as Central and Eastern European countries joined in the 1990s. Until then, the UCPTE system consisted of shared technical standards and organisational structures, while, to use Summerton's words, "still retaining the essential identity and autonomy of the individual systems" (Summerton, 1999: p. 93). Francis McGowan called this the "paradox of sovereignty", arguing that while national governments were trying to remain in control, regulatory responsibilities moved more towards the international level (McGowan, 1999: p. 137). In many ways, this system came about through the pragmatic extension of national systems with transnational flows as an additional European layer of efficiency and security, rather than the transformative and grand European vision. However, during this period we can see how it was not a matter of one replacing the other, they became interdependent.

4 Building the market regime

The European system which evolved over the 20th century was tightly-coupled, hierarchical, and dominated by monopolists. While European in character, it was primarily based on bilateral electricity exchange, and not multilateral trade. Yet, around the turn of the century a new grand vision was emerging, one of a European market. As part of the negotiations leading up to the Treaty of Rome (1957), cumulating in a European Economic Community, electricity and gas were discussed within the framework of a common market. However, it was argued at the time that the network-bound nature of energy rendered the introduction of market principles impossible (Lagendijk, 2011). Although energy (and thus electricity) remained on the agenda of the European Commission, the UCPTE tried to keep this at arm's length; it felt it already took part in European integration and spoke out against supranationalism. However, the pressure became too much as the Commission and key countries came to support European level electricity market liberalisation and the UPCTE became the subject of reform (Lagendijk, 2011). The vision of a European system thus became a vision of a market, whereby cross-border exchanges came to be commercial transactions and electricity would flow to where it is cheapest, regardless of national borders. This became the high level goal around which different types of political, industrial and technocratic actors cohered, particularly economic regulators, the Commission, and some national governments.

4.1 Background to electricity market liberalisation

The re-launch of European cooperation in the 1980s came with a renewed grand vision, one which included ambitious rhetoric on further completion of an internal market, including the postal, communications, and energy sectors, in order not to "drop back into mediocrity" (European Commission, 1985: p.57). Although the initial 1985 White Paper on the Single Market contained some proposals on energy, technical and political barriers were perceived to impose barriers on market functioning in monopoly sectors such as energy, telecommunications and water. This argument was spearheaded by Lord Cockfield, the vice-president of the Commission at the time (Buchan and Keay, 2016b). As a result, the liberalisation programme for electricity was side-lined in these early discussions about the internal market. However, in the years following the agreement of the Single European Act in 1986 energy liberalisation became more of a focus. The European Commission took up its role as the key driver of market-led integration, focusing on the application of treaty rules and the use of competition policy to open up cross border trade, public procurement of energy and the introduction of competition in monopoly sectors (European Commission 1988). The successful implementation of competitive electricity markets in Britain (England & Wales) and Norway in the early 1990s were significant in that they set a precedent and diminished the argument against liberalisation.

Although the initial target for implementation of a single market for electricity was 1992, it was not until 1996 with the First Energy Package[6] when substantial reforms began to be implemented. This was later followed by a more substantial Second Package in 2003[7], which began to restrict the discretion of member states by imposing the unbundling of generators and transmission networks and introducing regulatory regimes for third-party grid access. The key difference between the first and second packages was that unbundling and the regulation of third party access to the natural monopoly networks became mandatory and strict legal requirements were imposed upon member states (Squicciarini et al., 2010).

This period of change led to the creation of a number of new industry organisations and bodies which took the place of the previously dominant UCPTE. UCPTE became UCTE in 1999, indicating the separation of production and transmission, and a broader coordination body, European Transmission System Operators (ETSO), was formed with the aim of linking

[6] Directive 96/92EC concerning common rules for the internal market of electricity
[7] Directive 2003/54EC concerning common rules for the internal market of electricity. Regulation (EC) 1228/2003 on conditions for access to the network for cross-border exchanges of electricity.

a number of cross-border transmission bodies.[8] This period following the Second Package also saw the rise in prominence of a group who have since become increasingly influential in the integration process; energy regulators. The European Regulators Group for Electricity and Gas (ERGEG) was formed in 2003 (to be replaced by ACER in 2011) and its role was "to advise the Commission particularly in matters of implementation of energy market legislation, and to ease co-ordination among national energy regulators" (Jevnaker, 2015).

However, throughout this period the reach of the Commission was limited. It was not until the Lisbon Treaty, signed in 2007, that the EU gained a significant energy policy remit in the areas of energy market functioning, security of supply, interconnection and energy efficiency & renewables. However, reflecting the historically embedded balance of power and alignment of the national and European levels, it is made clear in the Treaty that this "shall not affect a Member State's right to determine the conditions for exploiting its energy resources, its choice between different energy sources and the general structure of its energy supply" (quote from Article 194 of Lisbon Treaty)[9]. This reflected the historically embedded balance of power and alignment of the national and European levels.

Much has been written about the overtly political aspects of implementing the IEM, focusing in particular on the contested liberalisation and unbundling process which was opposed by many Member States (Padgett, 1992: p. 54). This represented an important discontinuity which threatened to dismantle the established regime of national systems with limited cross-border exchange. However, this did not turn out to be case. During the 2000s the regime reconfigured itself and a new set of pan-European organisations and alliances emerged which became increasingly influential in developing the detailed rules, codes and frameworks for the IEM. A key development was the formulation of a "Target Model"; a high-level template for the European market.

4.2 Creating and implementing the Target Model vision

As has been outlined above, integration was initially on the basis of bilateral electricity exchange rather than a system of multilateral and coordinated trading with fluctuating prices determining power flows across borders. Since the 2000s however a process for developing and agreeing rules for cross-border trade was setup and at its centre was a new body; the Florence Forum of energy regulators. In the late 1990s the Commission established two such fora, Florence for the electricity sector and Madrid for gas, which meet bi-annually in order to "bring together national regulators and ministries with important market actors and stakeholders, in particular network operators as well as industry consumers and traders" (Eberlein, 2008: p. 78).

A key task for the Florence Forum was to advise the Commission on capacity allocation and congestion management (CACM) on cross-border interconnectors. The Electricity Cross-Border Regulation[10] which accompanied the Electricity Directive in the Second Package contained guidelines for managing CACM which were largely based on the traditional model

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[8] ATSOI (Island of Ireland); BALTSO (Estonia, Latvia and Lithuania); NORDEL (Denmark, Finland, Iceland, Sweden and Norway); UKTSOA (United Kingdom). For a short history see: https://www.entsoe.eu/news-events/former-associations/etso/Pages/default.aspx (Accessed 28.7.17)

[9] http://www.lisbon-treaty.org/wcm/the-lisbon-treaty/treaty-on-the-functioning-of-the-european-union-and-comments/part-3-union-policies-and-internal-actions/title-xxi-energy/485-article-194.html

[10] Regulation 1228/2003

of bilateral exchange and "explicit auctioning" – interconnector capacity is calculated and auctioned by TSOs based on "net transfer capacities" well in advance and largely separate from transactions in the wholesale electricity market. As a result, there was significant underutilisation of interconnector capacity across Europe, running counter to the new market paradigm. In order to enable a market where frictionless trade across borders was possible a more sophisticated method based on "implicit auctioning" – aligning the calculation and allocation of interconnector capacity with price signals in the wholesale market – was needed. Doing so was a significant technical challenge[11] and the design and implementation of such a method could not have been achieved without the technical expertise and cooperation of the TSOs.

The initial strategy for developing the rules for cross-border trade was a process of regional level experimentation and learning, the Florence Forum would act as an aggregator of these lessons and filter and communicate key findings to the Commission. The Commission amended guidelines to legally underpin the regional approach (Squicciarini et al., 2010) and in 2006 countries were grouped into seven Regional Energy Initiatives (REIs)[12], each with a regulatory coordination committee composed primarily of industry actors and a stakeholder group, an approach that Trinh and Meeus (2009) term the "Florence process". The key incentives for taking this regional and networked governance approach was to build collaborations and consensus behind the liberalisation agenda. This was, firstly, because of the Commission's "lack of supranational governmental powers" (Eberlein, 2008, p. 77), and secondly, to draw on distributed expertise. As illustrated in the following quote from Eberlein's analysis of the Florence Forum, there was strong resonances with the previous tradition of hidden integration: "These transnational coalitions are designed to further domestic reforms *without having to resort to the level of political decision making* by governments and legislators" (*ibid,* p. 77. Emphasis in orignial).

However, despite a recognition of the benefits of regional collaboration as a pragmatic means of achieving integration, it was only ever seen by the Commission as an interim phase (Squicciarini et al., 2010). During the 2000s the Commission became concerned that a regional approach could result in new lock-ins where incompatible systems developed in a fragmented manner. Around this time, they stated that "Market parties shall not be confronted with incompatible regional systems" (Commission, quoted in Squicciarini et al., 2010). The Florence Forum was mobilised in order to respond to and address this concern. In 2007 a temporary working group was setup called the Project Coordination Group (PCG) which comprised selected Commission, regulatory and industry personnel in order to

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[11] The problem is one of accounting for physical flows on an electricity network and aligning physical and commercial flows. In essence electricity in a network flows according to the laws of physics ('Kirchoff's laws') rather than those of economics, as explained by Van den Bergh et al.: "electricity does not flow directly from generator to consumer, but spreads out over all parallel paths in the network, according to Kirchhoff's laws. There is hence a fundamental difference between commercial flows (i.e., the shortest path in the network between generator and consumer) and physical flows through the grid" (Van den Bergh et al., *2016*). Electricity flows may not therefore follow expected routes if one was basing expectations on market signals, allocating transmission capacity to cover future demand in an efficient way is therefore technically challenging. The issue is most acute in highly integrated meshed networks, such as in Central and Western Europe, as oppose to simpler radial ones.

[12] "Baltic, Central-East, Central-West, Central-South, Northern, South-West and France-UK-Ireland" (Trinh and Meeus, 2009).

develop a higher level “Target Model” (TM) for system integration[13]. The PCG deliberated for a number of months and presented its views at the subsequent Forum meeting in 2008. They recommended a shift in emphasis away from the regional “two-layer approach” based around REIs, towards “a top-down approach” (Squicciarini et al., 2010). The Forum also requested that ETSO and Europex, the association of European power exchanges, jointly develop a proposal for market-based capacity allocation on interconnectors which would subsequently be trialled and rolled out across the IEM by 2015. Following a consultation process and a report (ETSO and EUROPEX, 2009) the TM vision which emerged from this process had as its key components price formation through day-ahead market trading and the management of interconnector flows using a market coupling methodology called “flow-based market coupling” (FBMC) which links rather than dissolves the existing national markets[14].

The subsequent 3rd Energy Package saw a formalisation of this regime with the creation of the Agency for the Cooperation of Energy Regulators (ACER) and the European Network for Transmission Systems Operators (ENTSO-E). ENTSO-E, along with being an industry coordinating body, was given a statutory role to co-develop, along with ACER, the rules for the IEM in the form of network codes. The new regulation on *conditions for access to the network for cross-border exchanges in electricity*[15] set out the creation of detailed code for CACM based on the FBMC methodology. CACM is just one of a number of codes relating to the formalisation of the IEM and the process for agreeing and implementing the various codes is itself a highly complex one.

5 Low carbon transition – can the market regime adapt?

Through the analysis above we have seen how the European electricity regime developed and was shaped by efforts to create a synergistic relationship between a high-level grand vision of a fully integrated system and the practical operation of systems, largely at the national level. A key source of coherence and strength in the European electricity regime has been an arrangement where complex scale alignments between regions, nations and the transnational level were possible. We have shown how this came about in the 20th century as consensus was built amongst powerful system actors that transnational

[13] The work of the project coordination group is detailed here: https://www.ceer.eu/eer_workshop/stakeholder_fora/florence_fora/pcg (Accessed 28.7.17)

[14] FBMC simplifies the system as each price zone, typically (though not necessarily) a national system, is seen as a single node. At the outset the FBMC methodology doesn’t interfere with or take into account flows within national markets. It takes as its starting point the existing structures of national markets and power exchanges which have developed at the various borders and uses a common algorithm used by TSOs and power exchanges to optimise interconnector capacity. Changes to the structure of price zones can be imposed however, if it is determined that transmission constraints in a particular part of the system are interfering with the operation of the market. FBMC is different from the approach which has been in use in the Nordic countries since the late 1990s. Here, rather than a number of power exchanges calculating interconnector capacity simultaneously using a shared algorithm, a single power exchange, the Norpool Spot, allocates interconnector capacity based on market signals and takes into account the entire system rather than individual interconnectors. This approach is referred to a market splitting because the system is divided into a number of price zones defined around constraints on the transmission grid. This is similar in ways to locational marginal pricing, a method in operation in the US which is generally favoured by economists because transmission constraints are calculated in real time at each node of the network rather than aggregated over larger price zones.

[15] Regulation (EC) No 714/2009

interconnection offers technical and economic efficiencies, and was later formalised in detailed regimes rules, methods, codes and governance structures for the IEM. As we outline below, a concern for proponents of the IEM is that the rapid deployment of renewable generation in some countries is undermining some of the basic principles and presumptions of the TM. A particular source of frustration for European market advocates has been the introduction of capacity mechanisms[16] in many countries in order to integrate renewables without compromising system reliability and capacity adequacy (European Commission, 2016). A fundamental principle of the TM is an "energy-only" market (EOM) where operational and investment decisions are made solely on the basis of price signals from the wholesale market. Providing revenue streams outside of the EOM to generators in the form of capacity payments is seen to interfere with this as the decision to invest in or shut down a power plant is to some extent de-coupled from the market (Bolton et al., 2016). To date the main response has been one of regime adaptation based on an ambition of maintaining continuity within the regime, with the high level goal of market-based integration remaining largely intact.

5.1 Resolving tensions in the market regime

The EU's recent Winter Package titled 'Clean Energy for All Europeans'[17] published in late 2016 sets out initial proposals to reform various aspects of the market in an effort to align national developments with the IEM, in particular the introduction of capacity mechanisms and renewable support mechanisms, which have to date been primarily orientated towards addressing national energy security and decarbonisation objectives. The Package contains proposals to link renewables support mechanisms to wholesale markets, to open up capacity markets to non-domestic providers, to introduce a common methodology for calculating capacity adequacy and to require nation-states to have a reliability standard in place which is then used as a basis to justify the introduction of any additional payments for capacity. Whether this rear-guard action against the potential renationalisation of energy policy and the effort to reposition the European market at the centre of the low carbon transition will succeed is uncertain.

Another unresolved issue which the market reforms will need to address is the changing spatial scale of energy system integration. Given that renewables and other low carbon technologies are increasingly being integrated at the distribution system operator (DSO) level, the Winter Package sets out to provide clarity on how future TSO-DSO interactions might be formalised. Historically TSOs have been the key system integrators and their central role in shaping the European system has been a strong continuity, essentially based on the idea of economies of scale in the generation and bulk transmission of electricity, and that the economic mix of generators is best achieved by sharing different types of geographically dispersed resources. However, a shift towards decentralised technologies and a more customer-centric, services based, energy system may challenge this economic logic and see the emergence of new system integrators (Bolton and Foxon, 2013). For example, DSOs may form new alliances with service providers and other actors who have

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[16] Various ways of providing revenue streams to providers of capacity, most commonly as strategic reserves or through a capacity market.
[17] Proposals are outlined in a number of documents. Available here: https://ec.europa.eu/energy/en/news/commission-proposes-new-rules-consumer-centred-clean-energy-transition. For a useful summary see (Hancher and Winters, 2017)

less of a strategic interest in increasing transnational flows. In this scenario, where most of the system change happens at the sub-national level, the high voltage transmission grids may become less central and evolve into systems for balancing and handling residual flows, as oppose to being conduits for bulk flows of power between sites of generation and consumption. Given the political power and influence of TSOs and the important role that DSOs are likely to play in the future, it seems unlikely that such structural issues will be addressed solely through regime adaptations.

5.2 A new grand vision?

It remains unclear therefore whether such structural issues can be resolved through pragmatic responses like the Winter Package, or whether a more discontinuous regime change involving the formulation of a new grand vision will be required. Most recently, the EU's own energy integration efforts came together in the strategy for a European Energy Union (Commission, 2015), aiming to integrate European energy policy in the areas of security of supply, energy markets, energy efficiency, climate action, and innovation. There is uncertainty as to whether this constitutes a new grand vision which coherently integrates market and decarbonisation objectives. Some recent scholarship has summarised the Energy Union as "the most significant policy idea that seeks to reform European energy governance, policy, and regional co-operation" (Szulecki et al., 2016, 548). Nevertheless, commentaries have also reminded us to be cautious of interpreting energy union as a complete overhaul of EU's energy and climate policy. Initially, scholars found it to be essentially a new iteration of familiar problems and terminology and that rather than a 'political' energy union, the strategy would result in a continuation of the established market approach to European energy integration (Fischer and Geden, 2015)(Dutton, 2015). At a time when Member States continue to be reluctant to share their sovereignty in energy matters (Judge and Maltby, 2017, Thaler, 2016), some commentators still argue that the strategy rather aims at offering incremental improvements to pre-existing European energy policies (Fisher, 2017).

Whilst it is easy to skeptical about the boldest promises of a political energy union in the EU, history show us that grand visions of European energy integration should not be entirely dismissed on the count of them being unrealistic. As we have shown, they have been an important guide and coordinating device for regulatory and market design processes in the past. However, in a policy area that is constantly evolving and subject to rapid changes, such as the impacts of the Brexit vote on energy markets, it is difficult to determine when and if the Energy Union might become significant enough to be called an overhaul of existing policies and recognized as a new grand vision.

6 Conclusions

In this paper we set out to analyse the historical development of Europe's electricity system and to identify tensions between the current market-based regime and the low carbon transition. Regimes, as defined in the socio-technical systems literature, are the rules that coordinate large technological systems like electricity supply. They gain stability from strong alignments of technologies and institutions. We discussed recent trends in the literature on transitions which analyses the long-term dynamics of regimes, and how some in this field are moving away from ex-ante assumptions about regimes as static and resistant to change, towards a more symmetrical approach which is based on empirically rich accounts of the internal dynamics of regimes and is more open minded about the adaptive capacity of incumbent actors and their potential to innovate. Rather than basing our analysis on the multi-level perspective on transitions, which tends to focus on external drivers of change at the landscape and niche levels, we sought to develop an account of how the European electricity regime developed and evolved over the decades through an alignment of *grand visions* and processes of *pragmatic integration*. Grand visions embody high level political ideals and economic logics around European integration and imply radical system change. As we have shown for the case of the European electricity system, they have developed alongside and become closely intertwined with more technical and pragmatic processes of system change which, since the post-World War II period, have tended to take place at the national level.

We developed a regime analysis of Europe’s electricity system and examined the historical origins of European electricity integration. This became strongly embedded in the decades around the Second World War. Following a period when radically different visions of what a European system could be were proposed, nation states emerged at the core of the system configuration, but the idea that the pursuit of technical efficiencies should not be constrained by territorial borders remained strong and this led to the creation of transnational forms of industry coordination and collaboration. This took different forms over the decades, initially as a process of technocratic “hidden integration”, which from the late-1990s evolved into a process of market-led integration. Although the European system did not develop according to a grand vision, in the sense of a top-down blueprint, a wider framing of a European system and the notion that technical efficiencies should be pursued regardless of territorial borders has endured and has acted as a key guiding vision and coordinating device for a heterogeneous set of actors and institutions. The shift towards markets in recent decades has not seen a fundamental change in this dynamic, rather it formalised the rules and codes for the previously loosely coordinated regime. Historical evidence suggests that the collection of organisations and institutions which constitute the regime of cross-border electricity exchange and trading in Europe has shown a remarkable ability to adapt and reinvent itself during different periods of transition, most notably following the liberalisation reforms of the 1990s and 2000s which threatened to undermine and dismantle it.

The question arises today as to whether this market-based approach to integration and its associated material and institutional configuration is compatible with the contemporary processes of low carbon transition. Uncertainties remain as to how low carbon technologies can be integrated into this system and whether this regime can adapt to potential technological, political and organisational disruptions and dis-continuities in the future. It is certainly possible that these potential discontinuities may culminate in a reversal of the momentum of the European electricity market and integration process. As it stands, even disregarding Brexit, the future of electricity in Europe is more likely to be characterised by multiple and differentiated energy transitions, with countries moving at different speeds and maintaining a national lens as they develop strategies and policies in line with their own industrial priorities and resource bases. The connection between market prices and costs for electricity generation are increasingly disconnected, thus de-coupling price signals and investment decisions. As a result, the long term viability of the current European electricity regime based on a wholesale market driving system change remains unclear.

We propose that our approach to socio-technical regime analysis offers useful insights to those involved in contemporary European energy policy debates. Much of what has been written about the EU's role in the decarbonisation of European energy systems examines the design and effectiveness of specific policy measures in isolation and typically does not analyse the low carbon energy transition in the context of the longer run trend of cross-border energy system integration, a process which has been taking place for almost a century. Whether interventions are aiming at disruptive or incremental changes to energy systems, their success will be based on an understanding of wider socio-technical regimes which underpin and provide stability to systems, otherwise the form of change will be marginal and superficial. Regimes are contextually embedded and have quite specific dynamics and features which can only be uncovered through empirical and historically informed analysis.

Successful policies and strategies aimed at enacting a low carbon energy transition in a European context, we argue, are likely to be the ones that are based on an understanding of the dynamics between grand visions and pragmatic integration processes and will seek to intervene and enact change at both of these levels. We suggest that what may be lacking is a new grand vision which creates a stronger political consensus around a European energy transition and which acts as a coordinating device for future regulatory changes and market designs. Currently these appear to be addressing problems as they arise, as oppose to anticipating change and reshaping markets in a more strategic way. In historical terms the current period of uncertainty and apparent openness may be similar to the early inter-war years when radically different visions of what a European system might be seemed possible. History shows us that there is no one vision of a European system, whether based on economic logics, political ideals or technological utopianism.

In the wider field of transition studies further work would be required to develop these insights about European energy policy and system change. This should focus on more in-depth studies of regimes; in particular, the nature, origins and evolution of the detailed technical rules, procedures and codes by which they operate. An adapted version of our framework of grand visions and pragmatic integration might serve as a basis for this as it links these internal technical features of regimes with wider political and social processes, without straying too far from the key unit of analysis. The continual broadening of transition studies as an academic field, we argue, risks diluting its original contribution – the understanding of socio-technical regimes and their long term evolution. The symmetrical approach to regime analysis developed here seems to fit well with a transnational regime such as European electricity which is very heterogeneous and relatively loosely coordinated, but it may not be the case for those embedded at the national or sub-national scales which may in fact be more ridged and resistant to change. Whatever the case, any claims about the nature and dynamics of regimes in transition studies should be based on historically informed empirical analysis.

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